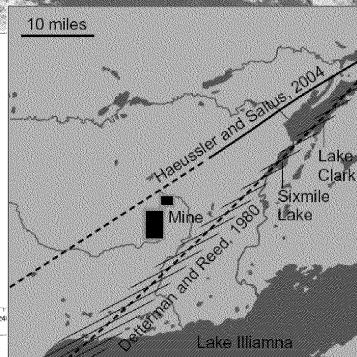
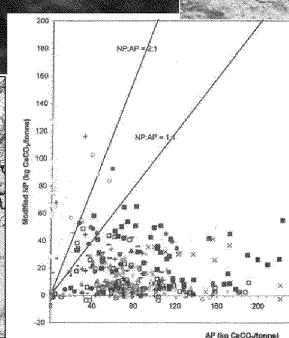


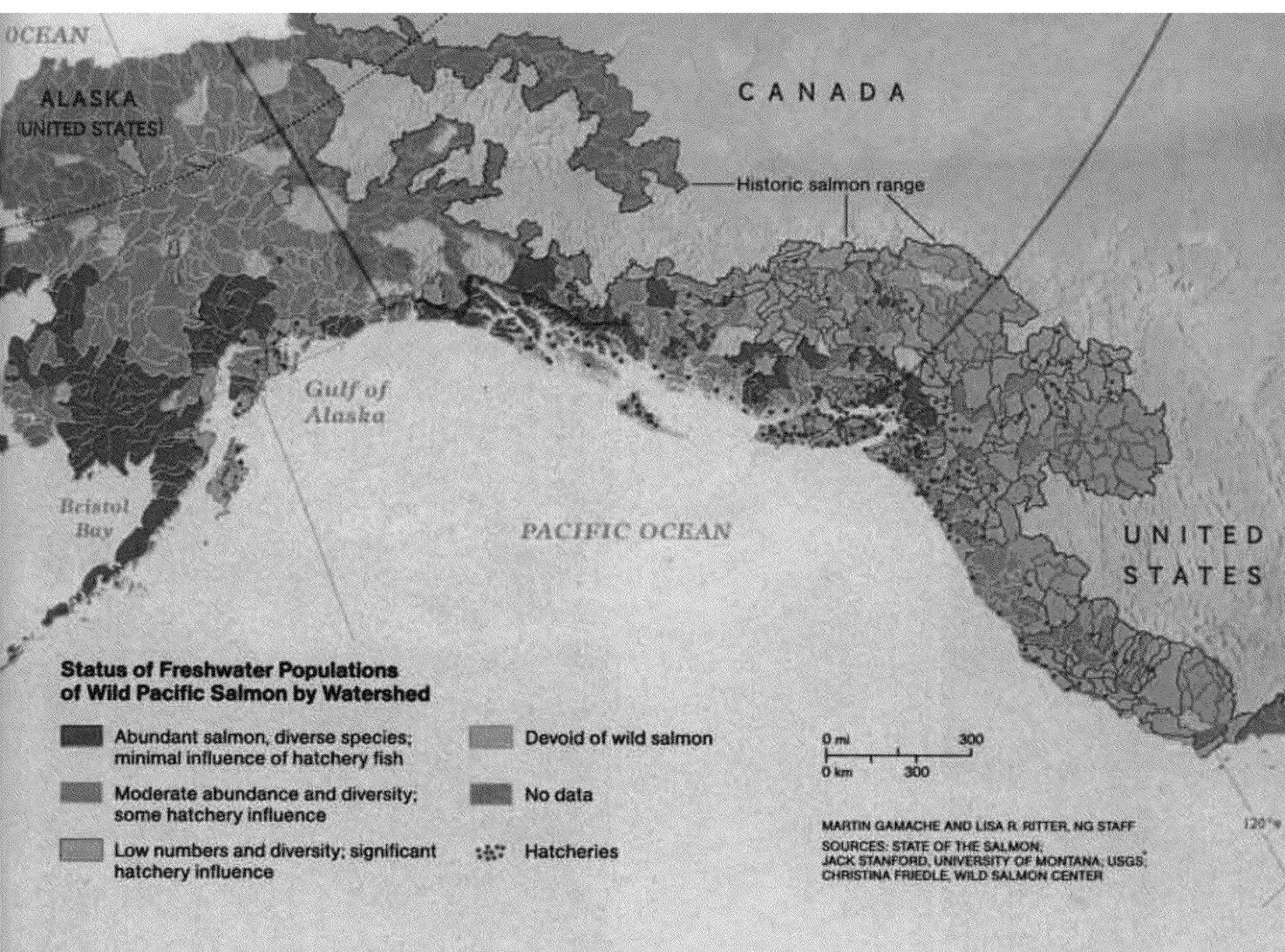
Bristol Bay & the Proposed Pebble Mine: Risks to Fisheries



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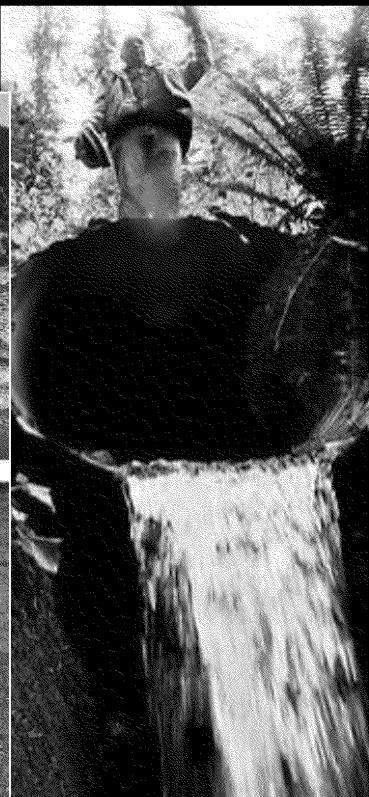


Kamchatka and Alaska offer the healthiest of the much diminished wild Pacific salmon habitats, supporting well over half the stock. With the increase in hatchery-bred salmon, the total catch has gone up, but hatchery fish compete and interbreed with wild salmon, threatening their viability.

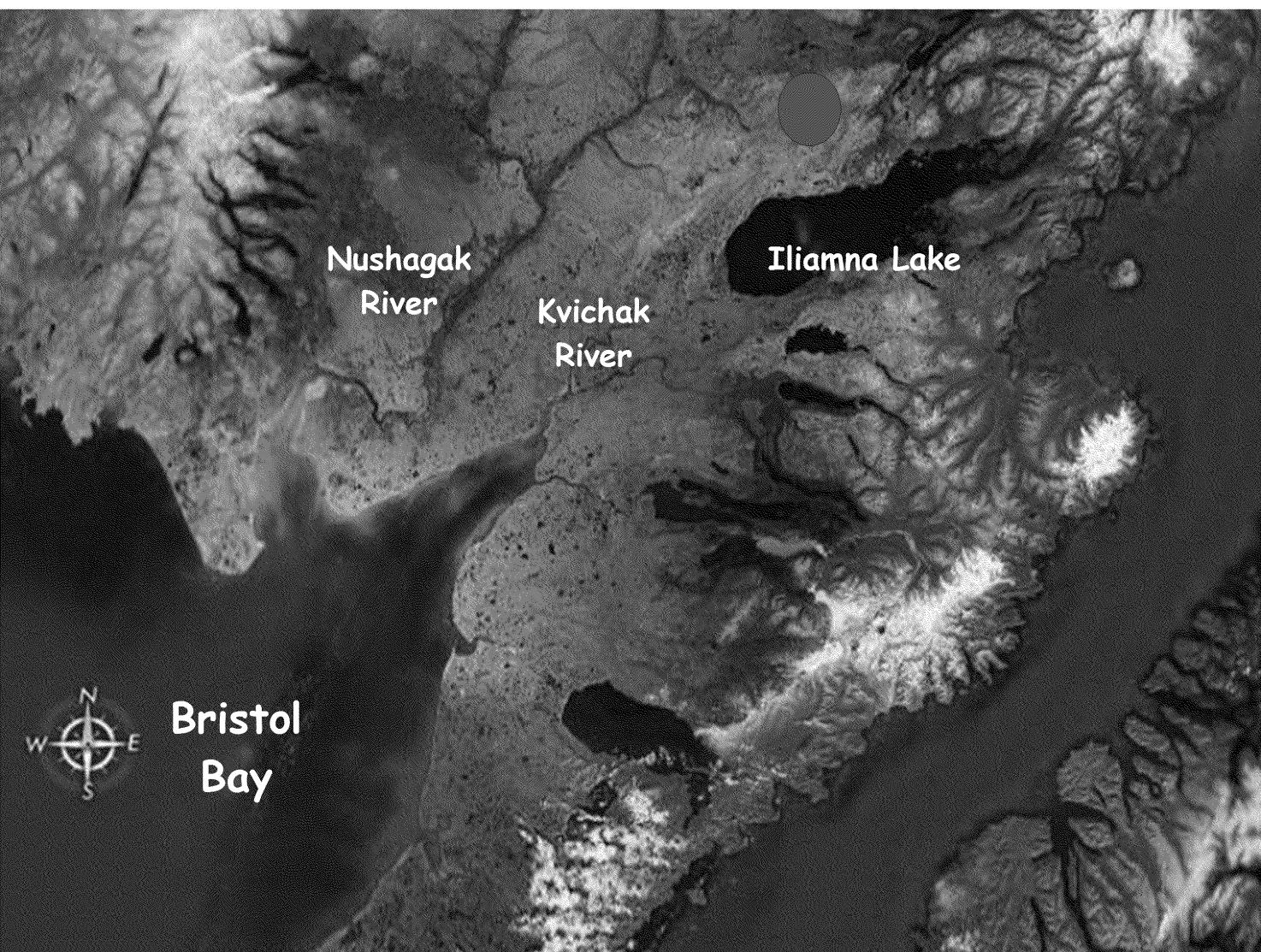


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Primary Reasons for loss of Salmon Habitat, loss, degradation, fragmentation



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The Bristol Bay Commercial Salmon Fishery

- Ongoing 125 years.
- Rare example of a sustainable fishery (MSC).
- AK produces about 92% of N. American sockeye; 51% is from Bristol Bay; over 60% of that is from the Kvichak and Nushagak
- \$100 M exvessel and ~ \$350 M annually



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IMPORTANCE OF SALMON TO ALASKA NATIVES

A black and white photograph showing a person from behind, wearing a dark apron, hanging numerous salmon on a wooden rack. A large speech bubble originates from the person's head, containing the text "That river, it's my grocery store".

That river, it's my
grocery store

Bristol Bay has the largest subsistence salmon harvest : ~150,000/yr

Cultural heritage, a way of life, and primary protein resource.



Sportfishing

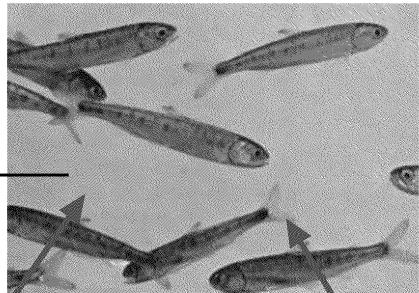
In 2005, an estimated \$61 million was spent in Alaska on Bristol Bay sportfishing trips (Duffield et al. 2007)

ECOSYSTEM SERVICES

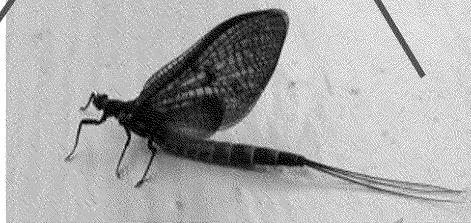
Salmon increase their weight >90% in the sea



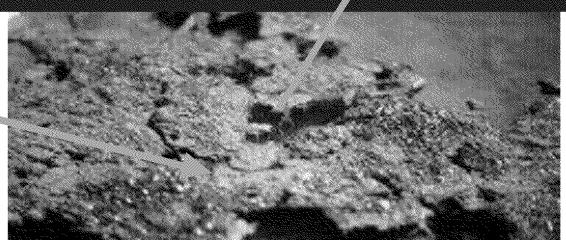
Young salmon show increased growth rates in response to salmon spawning.



Carry marine nutrients to the farthest corners of AK nutrient poor ecosystems



Biofilm growth influences insect numbers. Insect density can increase > 2500% in response to nutrient additions by salmon.



All anadromous salmon die after spawning.

Nutrients from carcasses increase biofilm growth.

The Pebble Prospect: One of many claims...

Pebble represents a claim of 153 mi² (red)

A total of 586 mi² (in yellow) of state land is staked.

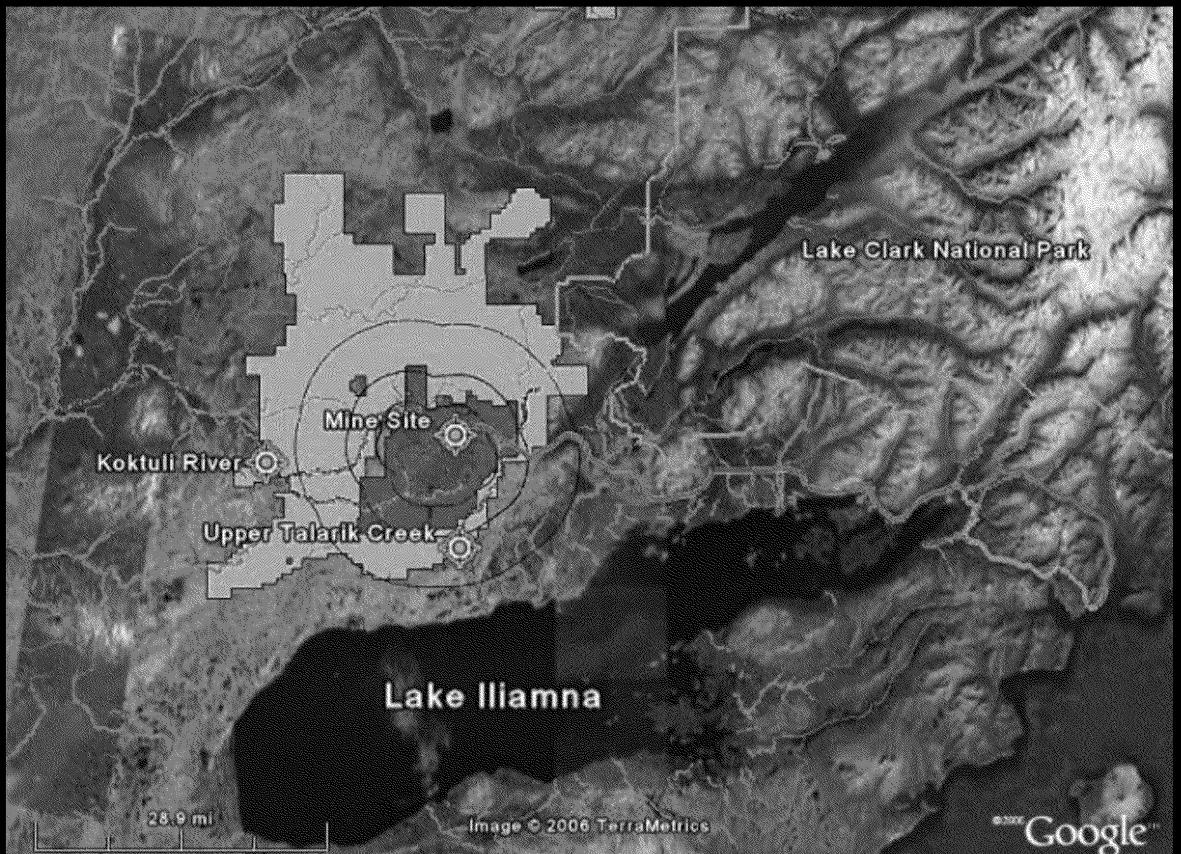


Image © 2006 TerraMetrics

Google

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ISSUES = WATER QUANTITY AND QUALITY



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Site Characteristics

- 9.1 billion tons of very low grade ore (<1% CuEQ)
- 72B lb Cu; 94M oz Ag; 4.8B lb Mo
- Porphyry deposit= has high acid generating potential
- Underneath headwaters of the 2 largest salmon systems: Kvichak and Nushagak; Upstream of 60% - 100% Bristol Bay fishery
- Porous soils
- Lots of groundwater feeds salmons streams
- Undefined groundwater boundaries
- Metals: Cu, Zn, As, Cd, Se, Mo, ...toxic to fish
- Seismically active region-faults remain undefined
- Subject to high winds
- Subject to floods
- Global warming will increase the severity and frequency of storms.

SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE



descent of smell

POLLUTION IMPAIRS OLFACTION

JANUARY 27, 2007 PAGES 49-64 VOL. 171, NO. 4

hibernation
aspirin de
brain damage pr
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AQUATIC NON-SCENTS

Repercussions of water pollutants that mute smell

BY JANET RALOFF

People complain about the way that fish smell. But it's the fish that should be doing the grumbling. In pristine waters, the animals smell quite well, thank you. Those tiny holes near fishes' mouths are, in fact, nostrils through which the animals draw in water to pump over olfactory nerves. By distinguishing scents, fish find food and mates and avoid predators.

Studies decades ago, for instance, showed that mechanically plugging the nostrils of adult salmon prevented them from locating their natal streams when they attempted to return home to spawn. The fish as juveniles had recorded memories of smells as they went to sea. Without detecting the olfactory signatures, the fish couldn't retrace their routes, says Nathaniel L. Schulte, a zoologist at the National Oceanic and Atmospheric Administration's (NOAA's) Northwest Fisheries Science Center in Seattle.

In a series of studies over the past 6 years, his group has demonstrated that metals and pesticides—at concentrations commonly found in streams—can impair a salmon's sense of smell just as effectively as plugging the nostrils did. Meanwhile, other scientists have shown that such pollutants block the sense of smell in other organisms.

"What we're finding," says Schulte, is that "even short-term exposure to many of these pollutants—on the order of hours—can interfere with olfaction."

Researchers have reported that the impairment can disrupt the animals' normal behaviors in several ways. Fish use their keen sense of smell not only to navigate dark and cloudy waters but also to nose out scents indicating danger, such as chemicals from a predator's skin. The studies are establishing that aquatic animals exposed to pollutants miss chemical cues that have life-and-death consequences, says toxicologist Gregory C. Pyle of Nipissing University in North Bay, Ontario.

PESTICIDAL NOSE PLUGS North America's most widely used herbicide blunts a fish's sense of smell, according to work by Keith Tierney and his colleagues at Simon Fraser University in Burnaby, British Columbia. The herbicide is sold under a number of trade names, including Roundup.

A 30-minute exposure to a 1 parts per billion (ppb) concentration of atrazine reduced the activity of olfactory neurons in chinook salmon (*Oncorhynchus tshawytscha*) by 11 percent, the researchers

reported last November at the annual meeting of the Society of Environmental Toxicology and Chemistry (SETAC) in Montreal. The animals' neural responses to alarm odors dropped by 45 percent. Higher doses of the herbicide triggered greater losses in smell; 100 parts per million atrazine eliminated any response to a predator's scent. River concentrations up to 20 ppb can occur briefly near farms that apply it, says Tierney.

Pure glyphosate, the active ingredient in Roundup, caused similar changes in salmon olfaction, although only at far higher doses than were required of the commercial herbicide formulation. At the November SETAC meeting, these researchers presented data showing that Roundup was 100 times as powerful as blocking fishes' sense of smell as was an equal quantity of pure glyphosate.

Atrazine contains a variety of ingredients added to glyphosate to increase the herbicide's adhesion to leaves and to retard its breakdown. Although these ingredients are listed as inert components on herbicide labels, Tierney's team concluded that they aren't inert as far as fish olfaction is concerned.

"I'd like to find out what those inert are," Tierney says, but he notes that pesticide manufacturers regard them as part of their proprietary recipe.

Tierney isn't alone in his concern over supposedly inert ingredients. Some 4.1 billion pounds of inert pesticide ingredients are applied annually to the U.S. environment, Christine E. Gruis of the University of Washington in Seattle and his colleagues reported at the SETAC meeting.

Because these compounds aren't lethal to untargeted organisms, they don't require identification on labels, the Seattle researchers note—though the inert may exert a subtle but substantial toxic effect on aquatic life. Gruis argues that "a new regulatory strategy is needed," which would require toxicity analyses of any supposedly inert ingredients.

Atrazine isn't the only chemical pesticide that can suppress a fish's ability to smell. Tierney's group showed that at exposures of about 10 ppb, the fungical wood-preservation known as IPB turned off olfaction in chinook salmon. The researchers described that finding in the August 2006 *Aquatic Toxicology*.

They also reported in the October 2006 *Environmental Toxicology and Chemistry* that the insecticide endosulfan and the herbicide trifluralin and 2,4-D can impair a fish's sense of smell.

Schulte's group, too, has made contributions to the list of pesticides that affect fish olfaction. Six years ago, that team showed that diazinon significantly impaired responses by Chinook salmon (*Oncorhynchus tshawytscha*) to alarm scents and reduced their success in finding their natal pools.

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